PROC. ENTOMOL. SOC. WASH.
87(2), 1985, pp. 335–340

ASSOCIATIONS OF MITES AND TIGER BEETLES (COLEOPTERA: CICINDELIDAE) IN SOUTHEASTERN ARIZONA

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Abstract.—This study presents evidence of associations between mites and tiger beetles. Adult females of *Trochometridium tribulatum* Cross were found on larvae of *Cicindela willistoni* LeConte and *C. fulgoris* Casey. Hypopodes of *Sancassania* sp. were found on larvae of two species and adults of one species of *Cicindela.* Though not confirmed, the specific associations are probably phoretic. These associations may be due, in part, to the co-occurrence of these tiger beetle larvae in salt-flat habitats with ground-nesting bees which may be more common hosts.

Although associations between carabid beetles and mites are known (Regenfuss, 1968; Nickel and Elzinga, 1969; Green, 1975; Thiele, 1977; Olynyk and Freitag, 1979a, b), the occurrence of mites on tiger beetles, which are closely related to carabids, has been less commonly reported. In his significant study of the Cicindelidae of the central United States, Willis (1967) mentioned only three cases of mite associations, all with adult tiger beetles. He found many adults of *C. circumpicta* LaFerte with heavy infestations of larval trombidiids under the elytra and uropodid mites on the legs and thorax of two museum specimens of *C. sexguttata* Fabricius. He also cited Ingram's (1934) report of mites on the legs and thorax of adult *C. haemorrhagica* LeConte. Nagano (1980) found erythraeid mites of the genus *Leptus* on this same species, also in southern California. Three other mites reported from tiger beetles are *Andrevella parkeri* André (Erythraeidae), *Hoplothrombium* sp. and *H. cicindelae* Floch and Abonnenc (Trombidiidae) (Welbourn, 1983). These studies provide little or no information on the nature of the mite-beetle relationships, and are associations involving adult beetles.

The paucity of reports of mites on tiger beetle larvae is probably because this stage has been much less studied than adults. Larvae may be more suitable hosts for mites than adults because they have long life cycles (1–3 years) and live in permanent burrows in the ground. In such habitats they may co-exist with ground-nesting bees, which have frequently been reported as hosts of mites (Krombein, 1962; Batra, 1965; Cross, 1965; Cross and Bohart, 1969; Eickwort, 1979). Relationships between mites and bees are quite diverse and include parasitism, phoresy and saprophagy. For example, many acarids have a specialized heteromorphic deutonymphal instar, the hypopus, which is resistant to extreme environments (Krantz, 1978). *Pyemotes* are phoretic on adult bark beetles and may feed on any or all of the host immature stages (Cross and Moser, 1971; Moser et al., 1971). Some phoretic species feed on fungi growing on dead bees (Cross and Bohart, 1969) or pollen (Eickwort, 1979).

Table 1. Tiger beetle larvae and associated mites from the Sulphur Springs Valley, Arizona.

Host Species	Habitat Type	No. of Sites	No. Host Indiv.	Mites*	
				Troc.	Sancas.
C. willistoni	Playa	3	148	+	0
C. fulgoris	Playa	4	131	+	+
C. viridisticta	Ditch edge	2	46	0	+
C. ocellata	Ditch edge	3	188	0	0
C. haemorrhagica	Pond edge	2	81	0	0
C. pulchra	Saltbush flat	3	59	0	0
C. lemniscata	Saltbush flat	4	85	0	0
C. debilis	Grassland	3	23	0	0
C. obsoleta	Grassland	2	106	0	0
C. marutha	Sand ridge	8	213	0	0

* + = mites present; 0 = not present.

During studies on the ecology of tiger beetles in southeastern Arizona, mites were found attached to larval and adult tiger beetles collected in the field. This paper presents results of these field surveys and laboratory observations. It adds to an initial report of *Trochometridium tribulatum* Cross on some larvae of this tiger beetle community (Knisley and Pearson, 1981).

Materials and Methods

Most host beetles were collected during July and August of 1979–1983 in the Sulphur Springs Valley (Cochise Co.) of southeastern Arizona. This long, isolated valley is an area of internal drainage with a large, dry lake bed, the Willcox Playa, which drains the surrounding mountains (see Rumpp, 1977; Knisley and Pearson, 1984, for a more detailed description). With 20 species of tiger beetles this area has one of the highest cicindelid species densities in the United States.

Larvae of ten species of tiger beetles were surveyed in various habitats by visual search for larval burrows. A grass stem was placed into the burrow and the soil dug away to expose the larva. The larvae were placed in vials with soil, stored in the laboratory at 8–20°C for several hours, and subsequently examined under a dissecting microscope (at 20–50×) for attached mites. Most larvae were killed and fixed in hot 10% formalin (Maser, 1971) and stored in 75% ethanol. Other larvae were transferred to clear acryllic tubes (3 × 20 cm) filled with soil, for rearing and observation.

Adult tiger beetles were also collected, placed in killing jars, examined for attached mites and either pinned or preserved in ethanol. Representative mites were removed from adult and larval hosts and mounted in a modified Berlese medium (Krantz, 1978).

Results

Over 1000 larvae representing ten or more individuals for each of ten species of *Cicindela* were collected from 30 sites and examined for mites (Table 1). Twenty or more adult tiger beetles of each of 17 *Cicindela* species totaling over 600 specimens were collected from 28 sites and examined for mites.

Two species of mites were found on larvae of three and on adults of one cicindelid species and from three sites (Table 2). Adult females of *Trochometrid-*

Table 2. Summary of number of mite species and hosts in southeastern Arizona.

Mite sp.	Host Species	Host Stage[1]	Site[2]	Year	Hosts		Mites		
					No.	% Infec.	No.	No./Host	Range
T. tri.	*fulg.*	2	a	80	7	0	0	0	0
T. tri.	*fulg.*	3	a	80	26	38.5	125	12.5	1–45
T. tri.	*fulg.*	2	c	80	12	0	0	0	0
T. tri.	*fulg.*	3	c	80	22	0	0	0	0
T. tri.	*will.*	2	a	80	34	26.5	85	10.6	2–26
T. tri.	*will.*	3	a	80	32	9.4	2.9	15.8	2–16
T. tri.	*will.*	2	b	80	15	0	0	0	0
T. tri.	*will.*	3	b	80	13	0	0	0	0
Sancas.	*fulg.*	3	c	80	9	11.1	3	3	3
Sancas.	*fulg.*	3	c	82	34	26.5	86	10.5	1–56
Sancas.	*pime.*	AM	c	79	22	0	0	0	0
Sancas.	*pime.*	AF	c	79	25	24.0	20	3.0	1–6
Sancas.	*pime.*	AM	c	80	22	4.5	1	1	1
Sancas.	*pime.*	AF	c	80	16	0	0	0	0
Sancas.	*viri.*	3	d	83	17	77.3	149	11.4	1–52

[1] AM = adult males, AF = adult females.

[2] Sites are all in Cochise County, Arizona as follows: a. 8.0 km WSW of Willcox (on Willcox Playa); b. 8.8 km WSW of Willcox (on Willcox Playa); c. 13 km WSW of Willcox (edge of Willcox Playa); d. 4 km N Kansas Settlement.

ium tribulatum Cross were found only at one site (a), the Willcox Playa, and only in one year, 1980, when both *C. willistoni* LeConte and *C. fulgoris* Casey were infested. Second and third instars of the former species and third instars of the latter species had mites. Interestingly, both species occurred together in the same microhabitat, though in other years *C. fulgoris* was along the playa edge and over 100 m from *C. willistoni*. Several other populations of these species at nearby similar sites (a, b) did not have mites (Table 2).

Hypopi of an acarid mite, *Sancassania* sp. were found at two sites on larvae of two and adults of one species of *Cicindela* (Table 2). Nine of 34 *C. fulgoris* third instars in 1982 and one of nine third instars in 1980 from a playa site different from that described above were infested with mites. At this same site several adults of *C. pimeriana* LeConte also had mites. In March 1983, *Sancassania* was also found on 17 of 22 third instars of *C. viridisticta* Bates collected along an irrigation ditch. Larval density at this site was very high, from 6–20 larvae/m.

The mean numbers of mites per host for these two species of mites on the four species of beetles were similar, but the range per individual host and the host attachment sites were not (Tables 2, 3). Preferred attachment sites for *T. tribulatum* were the dorsal surface and the abdomen. Most of the *Sancassania* sp. were attached ventrally and on all body regions, though relatively few were on the thorax. The legs of *C. viridisticta* and the head capsule of the *C. fulgoris* also had many *Sancassania* sp. The mites on the adult *C. pimeriana* were primarily on the ventral surface of the abdomen and on the legs.

Among the mite-infested larvae of *C. willistoni* and *C. fulgoris* that were reared, no adverse effects were apparent. The survival time and mortality rates (25–35%) were similar to larvae without mites. Most mites died or were lost from the larvae

Table 3. Attachment sites of mites on tiger beetles from Southeastern Arizona.

Mite sp.	Host		No. of Mites	No. Mites/ Host	No./Attachment Sites					
	Sp	Stage			Head	Thor.	Legs	Abdo.	Dor.	Vent.
T. tri.	*will.*	L	104	5.5	9	19	10	66	83	21
T. tri.	*fulg.*	L	128	11.6	11	26	5	86	110	18
Sancas.	*fulg.*	L	86	9.6	32	8	8	38	28	58
Sancas.	*viri.*	L	141	8.8	23	8	60	50	51	90*
Sancas.	*pime.*	A	21	3.0	2	1	6	12	2	19

* Mites on legs recorded as ventral.

after several months of rearing. All of the third instar *C. viridistica* were reared and closely observed until their emergence as adults in June or July. Most (>80%) of both mite-infested and control larvae emerged. No differences in survival, behavior, or developmental times were noted. The two larvae with the heaviest mite burdens, 56 and 24, survived and emerged as adults. The latter individual had two attached mites present on the newly emerged adult.

Discussion

Results of this study give evidence of an association, probably phoretic, between mites and tiger beetles in southeastern Arizona. The observed associations may have developed from or be coincidental to the co-occurrence of tiger beetles in the same salt-bush habitats with ground-nesting bees. *Trochometridium tribulatum* is widespread in the United States and known primarily from the nests of various ground-nesting bees (Cross, 1965; Cross and Bohart, 1969). These mites are fungivores that can develop in colonies with dead bee larvae, then disperse in the adult female stage on adult bees (Cross and Bohart, 1978). The movement of *T. tribulatum* from bees to tiger beetle larvae seems likely since bees were especially abundant on the playa the year that mites were found on tiger beetle larvae. Cross and Bohart (1978) suggested the presence of this mite species on scarab beetles in the Sudan was due to dispersal from ground bees.

Mites could exist for extended periods on tiger beetle larvae or in their burrows. Food in the form of fungi growing on dead larvae or larval prey remains is abundant since larval mortality is high. Dispersal would be possible as larvae leave their burrows during flooding and dig new ones.

The numbers of *T. tribulatum* per host, percent of hosts with mites, and attachment sites were generally similar to what Cross and Bohart (1969) found on alkali bees in Utah. Such levels, they suggested, may indicate a permanent relationship.

The somewhat broader host (adults and larvae) and habitat range of *Sancassania* on tiger beetles may suggest this species is an opportunistic phoretic and only accidental or transitory on tiger beetles. Such relationships frequently exist for phoretic species (Cross and Bohart, 1969). Homann (1933) found few of the 18 species of phoretic mites of honey bees had any permanent relationship to individuals or to the colony. *Sancassania* is well known as a phoretic or saprophage of beetles and commonly feeds on dead hosts (Jarvis, 1964; Chmielewski and Lipa, 1967; Saminsak, 1971; OConnor, 1982; Eickwort, 1983). The presence of these mites on tiger beetles may result from their dispersal through the soil (B.

M. OConnor, pers. comm.) and be enhanced by the favorable habitat and high mortality of the larvae. Mites on adult *C. pimeriana* may have moved onto adult beetles during oviposition or burrowing by the beetles.

The phoretic associations suggested here are somewhat unusual in that they involve the non-parasitic stage of mites and the larvae of holometabolous insects. Most phoretic mites are associated with adult insects or are parasitic on immature stages. Tiger beetle larvae or their burrows are apparently favorable for mite survival, and may perhaps allow for development and occasional dispersal. Further studies on the specific interrelationships involved here are needed to determine if mites live their entire lives in association with tiger beetles.

Acknowledgments

I thank the following for their assistance: D. L. Pearson for the opportunity to initiate these tiger beetle studies; D. R. Beatty and M. R. Carter for assistance in the field; E. E. Lindquist for information on possible relationships of the mites and for reviewing the manuscript; B. M. OConnor for the identification of *Sancassania*; E. A. Cross for identification of *T. tribulatum* and comments on the manuscript; and to D. Brzoska for checking tiger beetle adults in his collection for mites. This research was supported by grants from the National Science Foundation to the author (DEB8119256) and to D. L. Pearson (DEB7803172).

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